Towards sub-fs x-ray plasma based lasers
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Modern table-top x-ray plasma lasers produce high energy pulses (up to several mJ) but of rather long picosecond duration. It limits their application for dynamical imaging of fast processes in nanostructures and micromolecules, including the processes induced by the laser radiation. We suggest two new approaches for generation of the intense attosecond pulses by the X-ray plasma lasers in the soft x-ray range: (i) seeding of the x-ray plasma based laser with a train of attosecond pulses produced via high-harmonic (HH) generation, and generation of the attosecond pulses directly by the x-ray laser. Both approaches can be achieved via interaction of the x-ray plasma laser radiation or the high-harmonic radiation, accordingly, with the resonant medium modulated by a moderately strong IR or visible laser field similar to the techniques discussed in [1]. However, contrary to [1], the case of a high density plasma, corresponding to the strong plasma dispersion, as well as the case of two stage amplifier, allowing for generation of attosecond pulses in the absence of any seeding radiation are studied.

In particular, the possibility to strongly amplify a train of attosecond pulses (produced via HHG) with a carrier wavelength 3.38nm (in a “water window” range) in inverted plasma of the resonant hydrogen-like C VI ions driven by an IR field with a wavelength $\lambda_{IR} = 2102.85\text{nm}$ and intensity $I_{IR} = 2.7 \times 10^{15} \text{W/cm}^2$ is illustrated in Fig.1. The C VI ion concentration and electron densities are chosen to be $N = 10^{19} \text{cm}^{-3}$, $N_{el} = 15N$ (corresponding to the maximum gain in x-ray plasma laser at 3.38nm based on C VI ion [3]).

![Fig. 1 Amplified z-polarized (red) and y-polarized (blue) X-ray pulses at the output of 1 mm of modulated inverted C VI plasma medium plotted for different peak pulse intensities of an incident z-polarized field: $I_{\text{u}} = 10^3 \text{W/cm}^2$ and $I_{\text{u}} = 10^2 \text{W/cm}^2$ accordingly.](image)

References